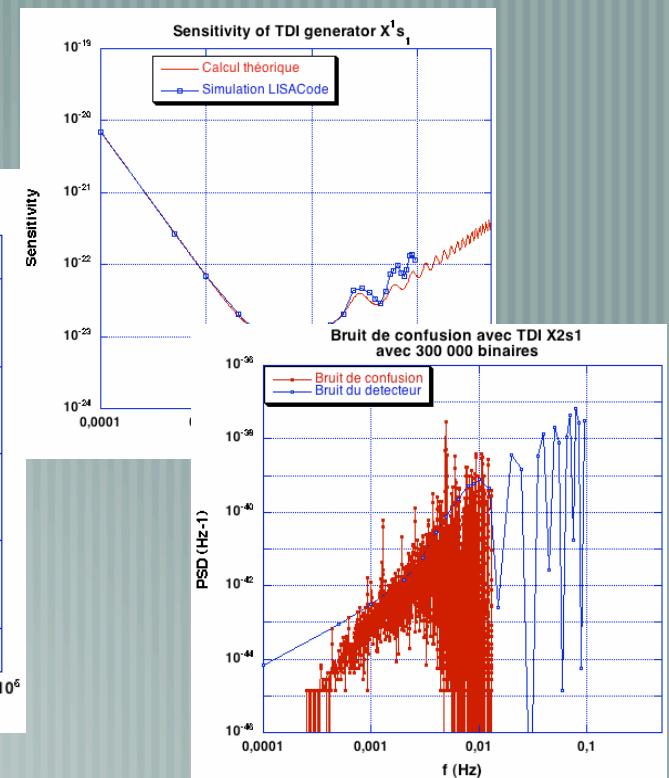
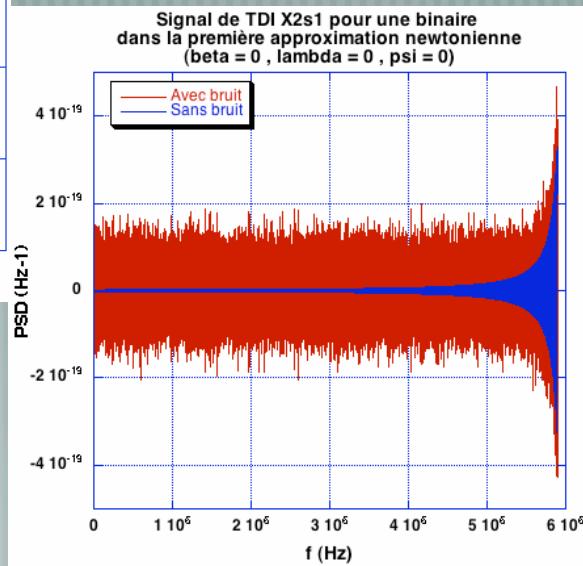
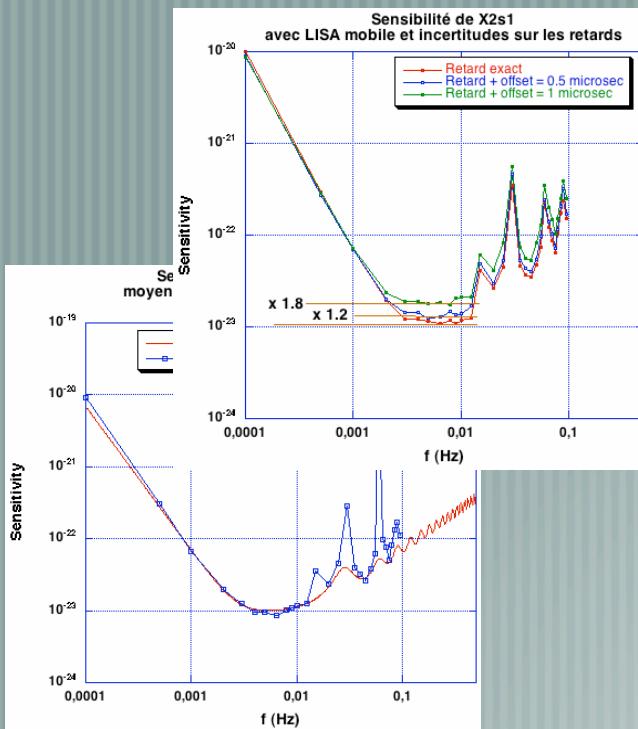


LISACode

Simulating LISA



Eric Plagnol
on behalf of APC and Artemis (Lisa-France)
LISA Symposium - June 2006



Outline of the presentation

- [Why another Lisa simulator ?]
- [Basic Principles and structure of the code
 - The LISA sensitivity curves
 - Modifying the armlengths.
 - Introducing an error on the delays
 - GW : an example
 - The galactic confusion noise
- [Status and evolution of the code]
- [Summary]



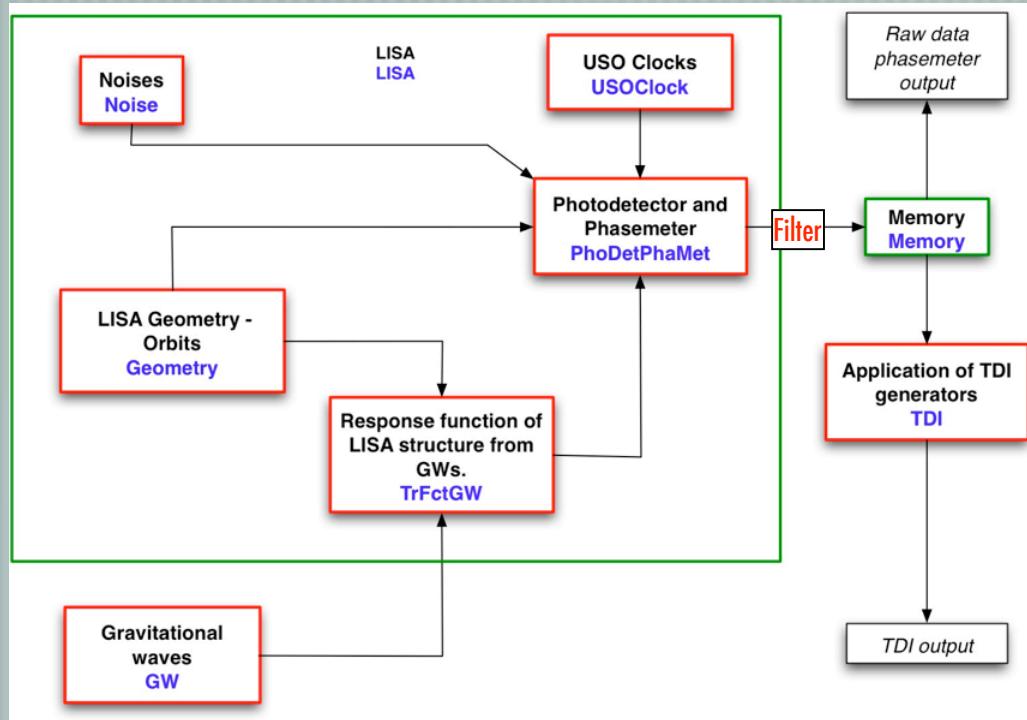
Why another Lisa Simulator ?

- [A contribution to the European effort (ESA/DAST),
- [Participation to the Mock data Challenge and the analysis,
- [it is an asset to have multiple/different codes,
- [A learning experience...for us !
- [Thanks are due to M.Tinto and M.Vallisneri



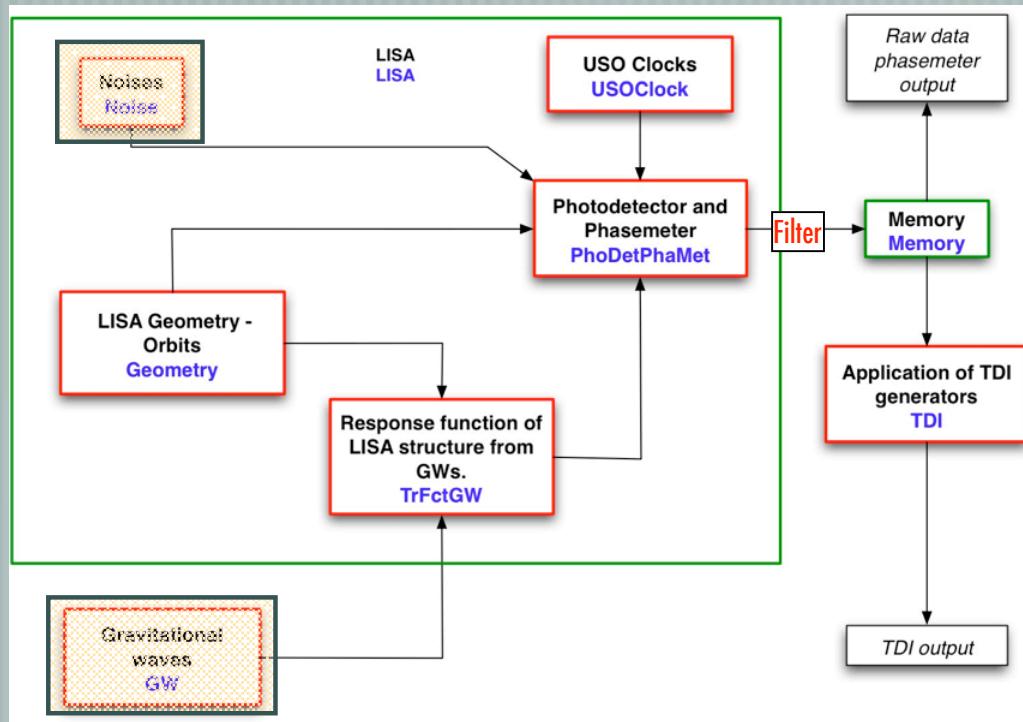
Basic Principles and structure of the code

- Inputs : Gravitational Waves (and noise).
- Outputs : Time sequences : phasemeters and TDI



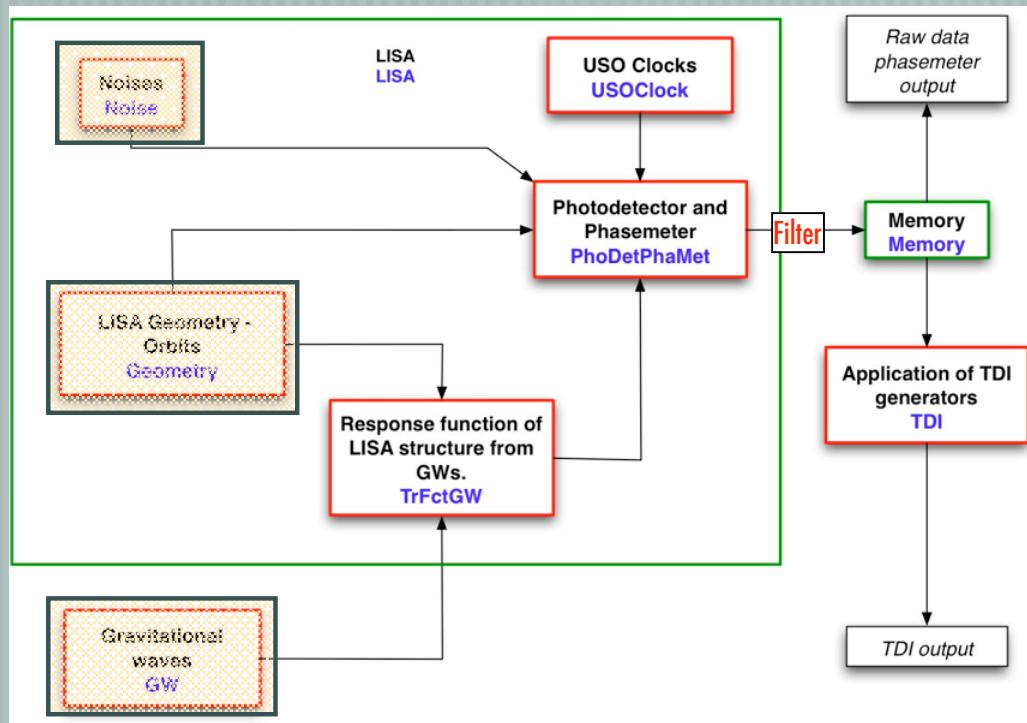
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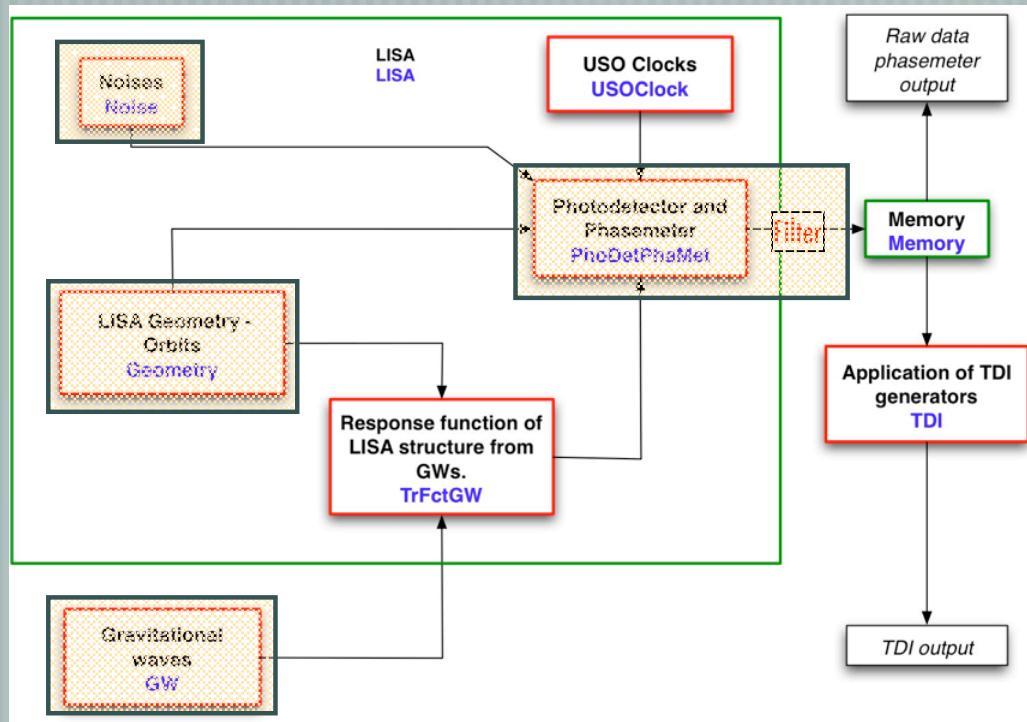
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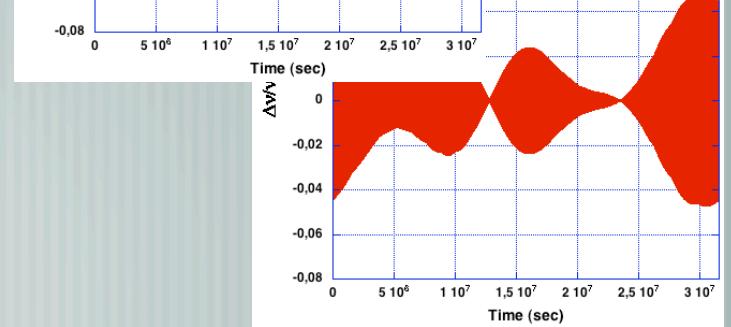
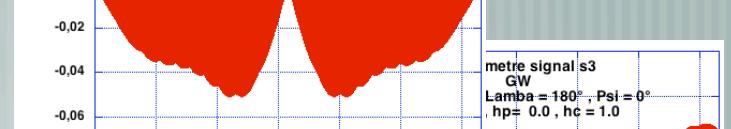
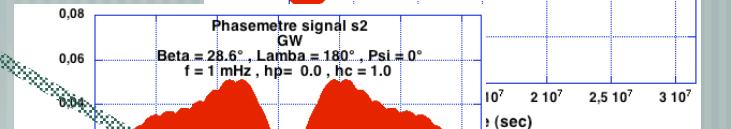
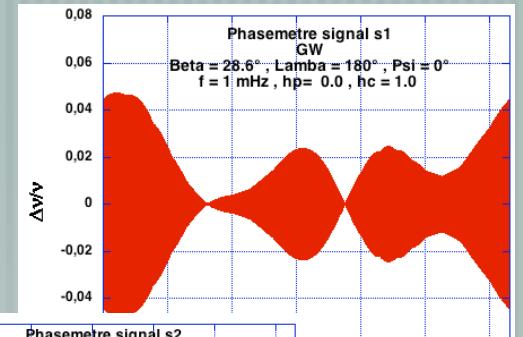
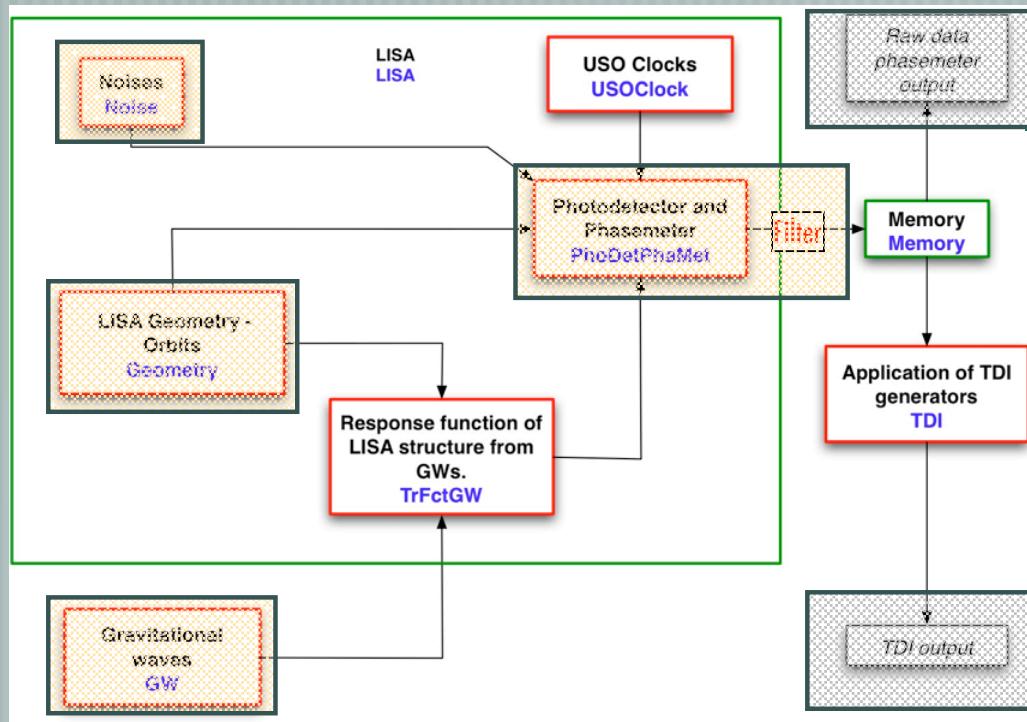
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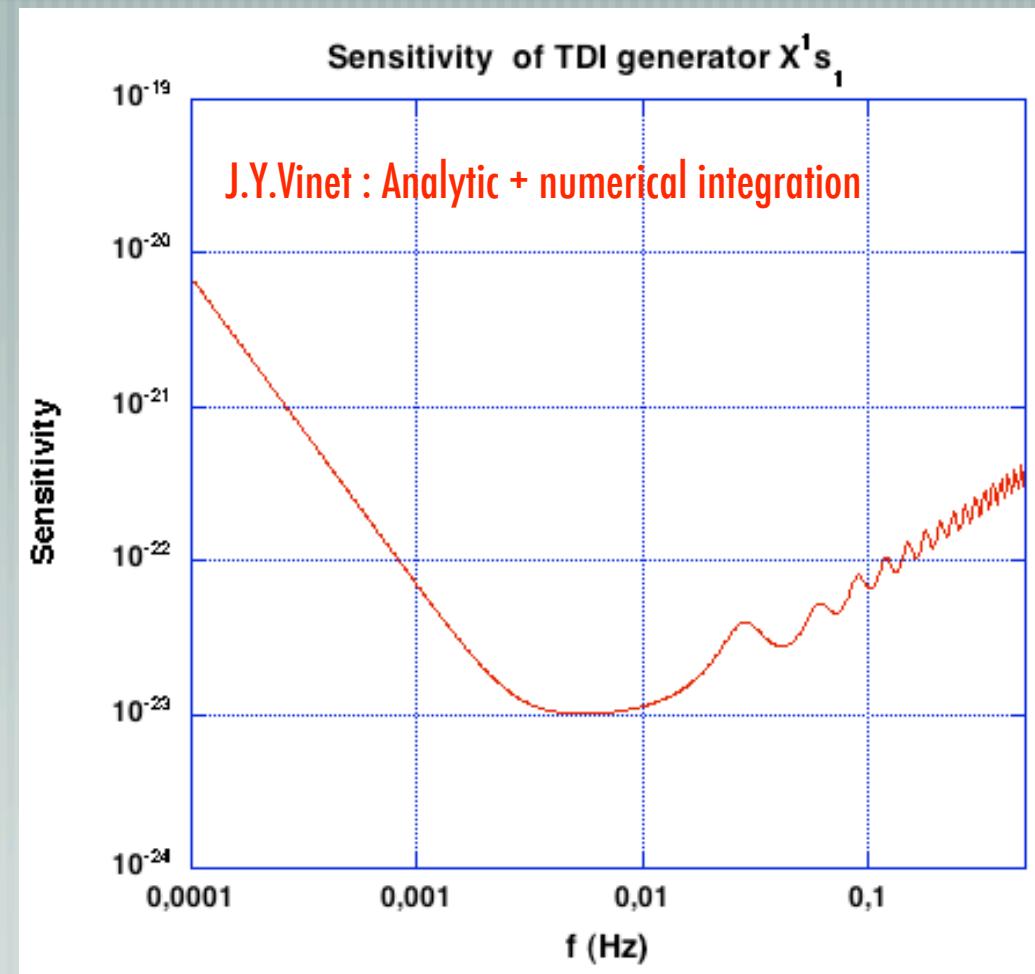
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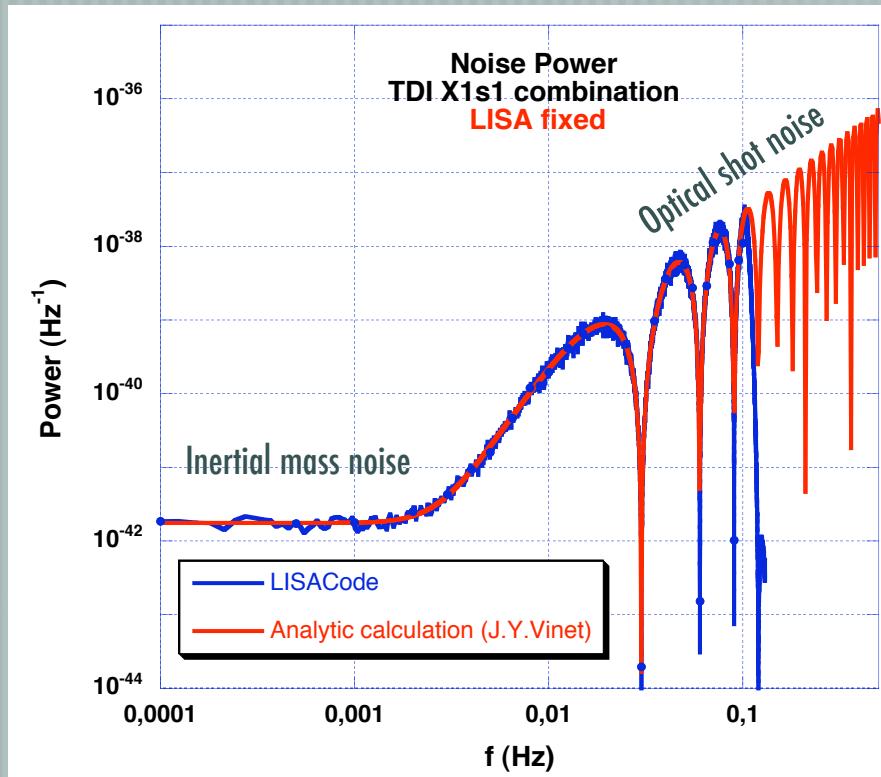
The LISA sensitivity curves : 1

- Lisa is fixed : no flexing or Sagnac
- TDI first generation... of course.
- Isotropic distribution of sources



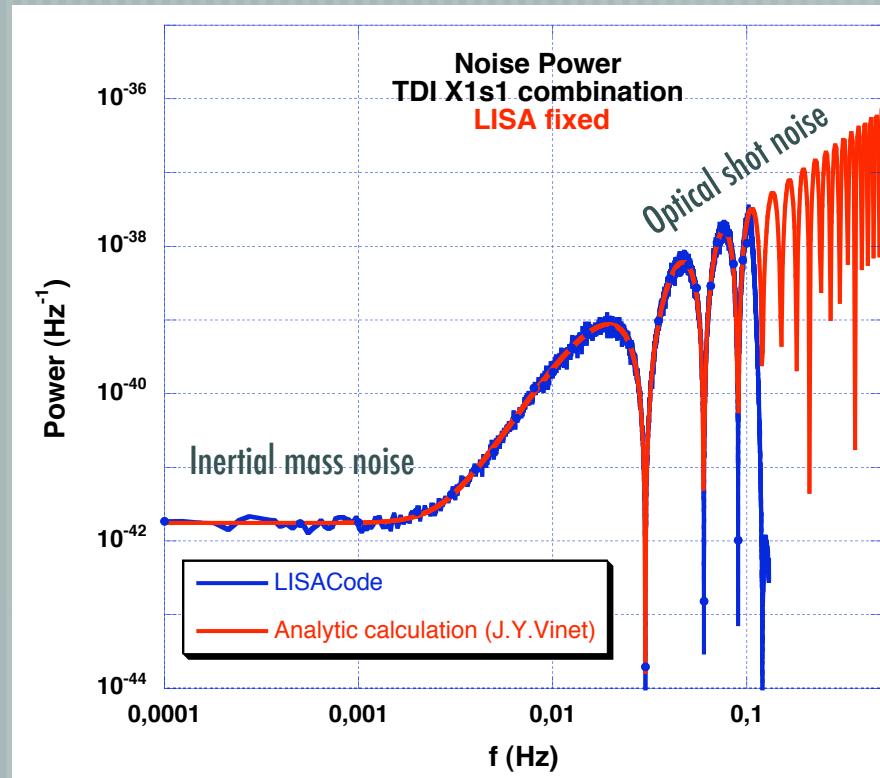
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- Standard noises (Pre-Phase A report)
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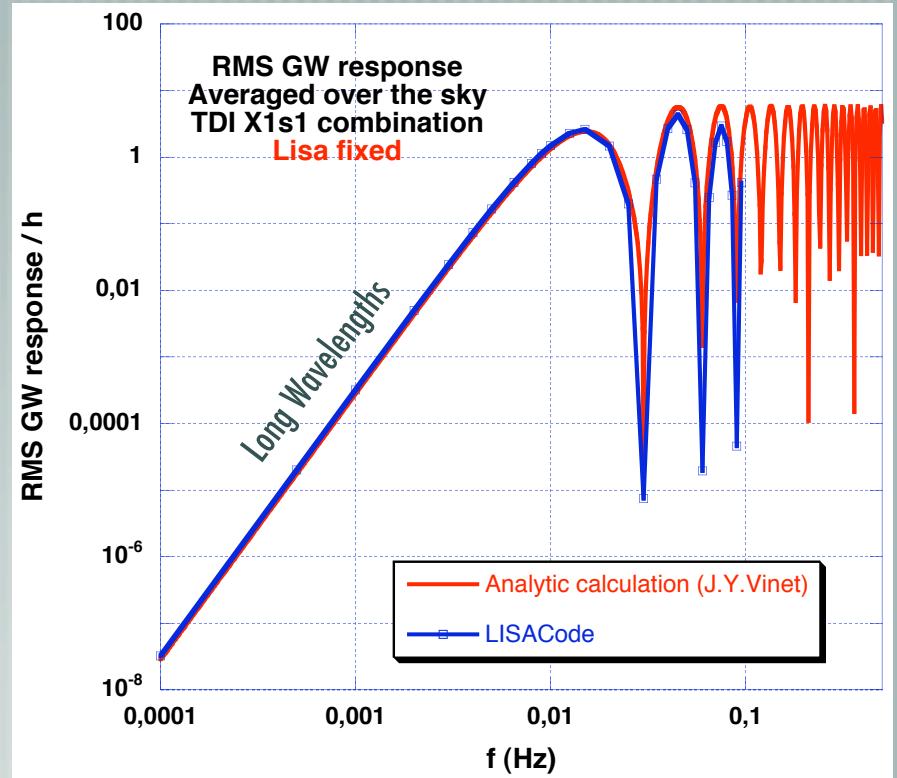


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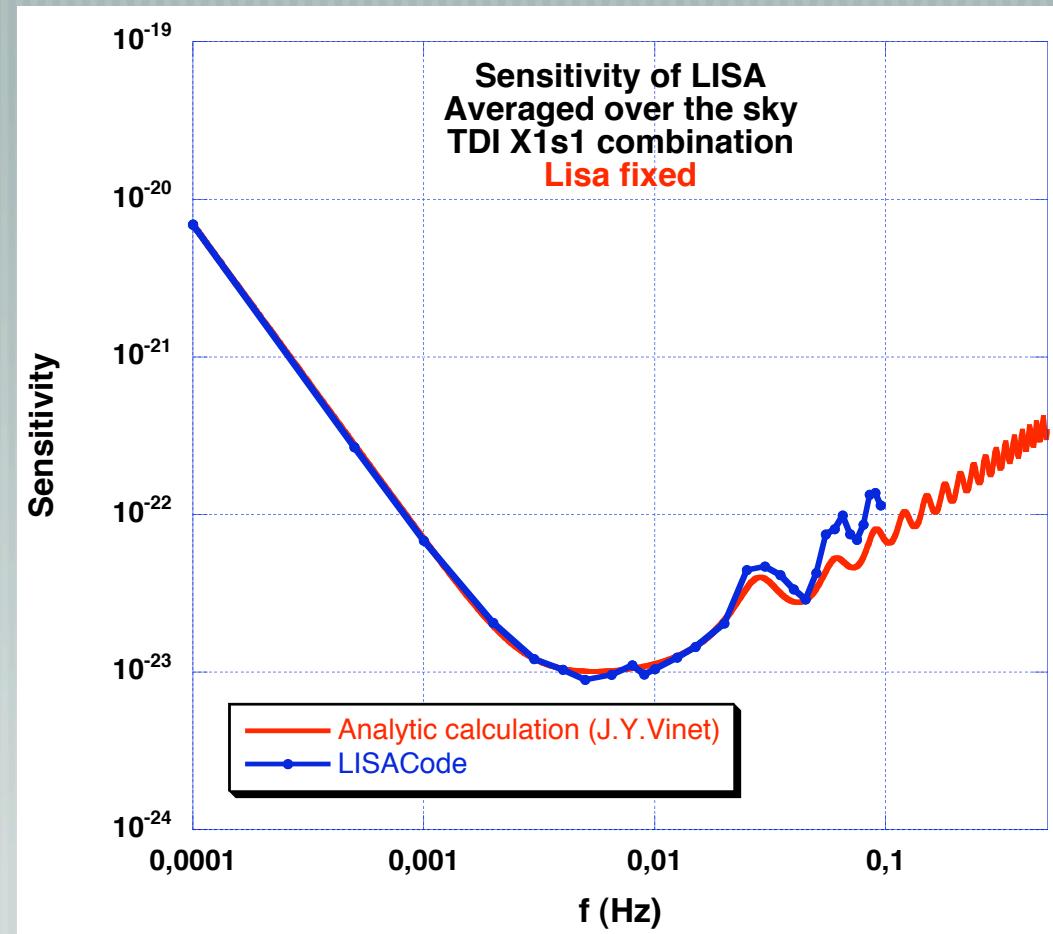
The LISA sensitivity curves : 1

Sensitivity

$$h = 5 \sqrt{\frac{Noise}{Yr * Resp_{GW}}}$$



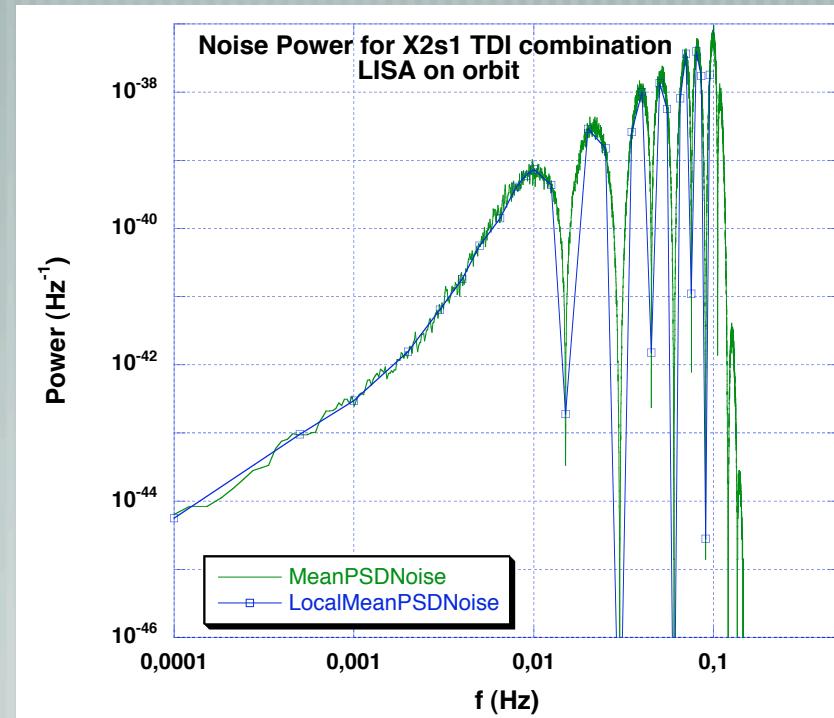
Validation of LISACode



The LISA sensitivity curves : 2

Lisa on realistic orbits : Sagnac + Flexing

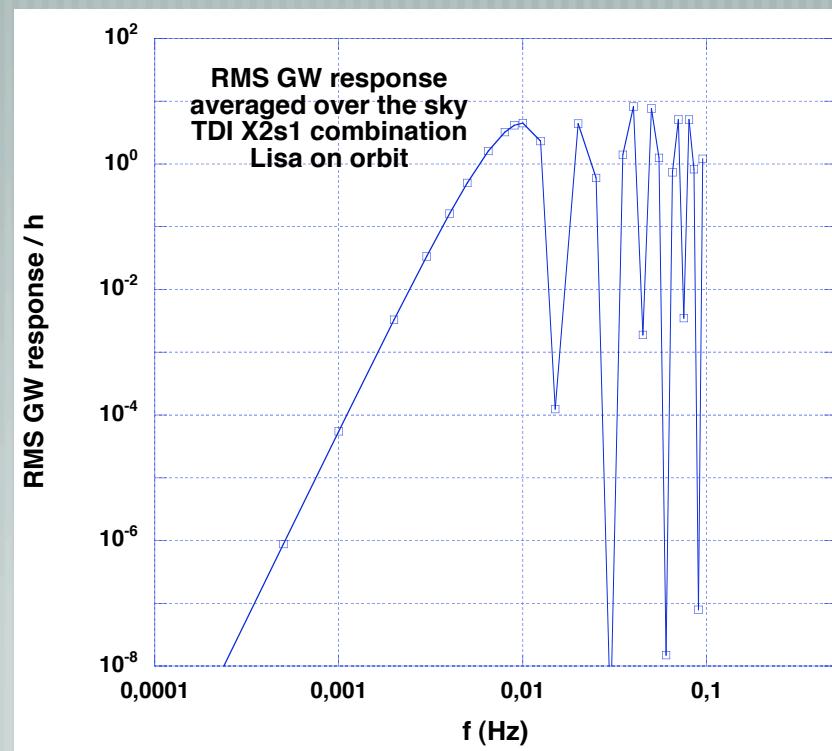
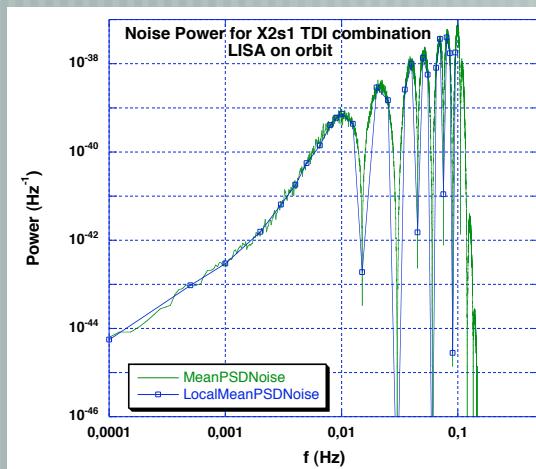
TDI 2nd generation



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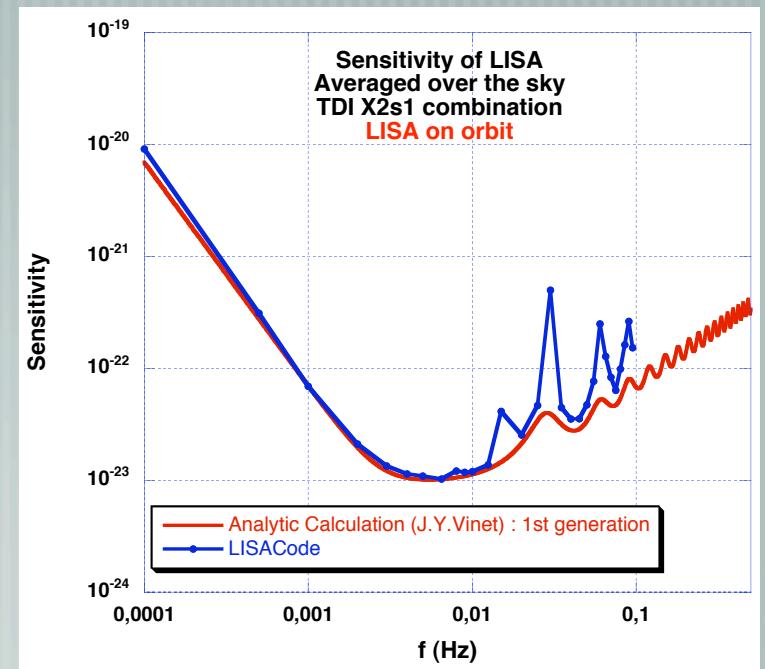
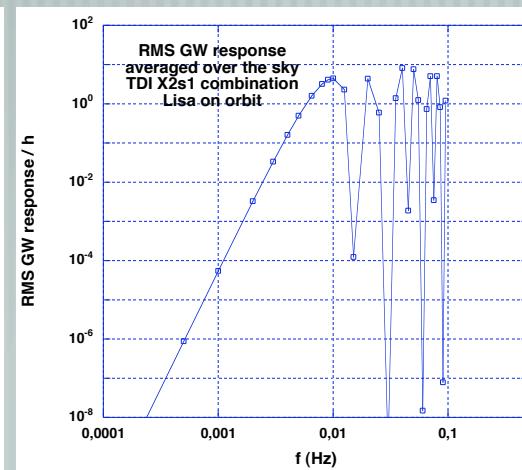
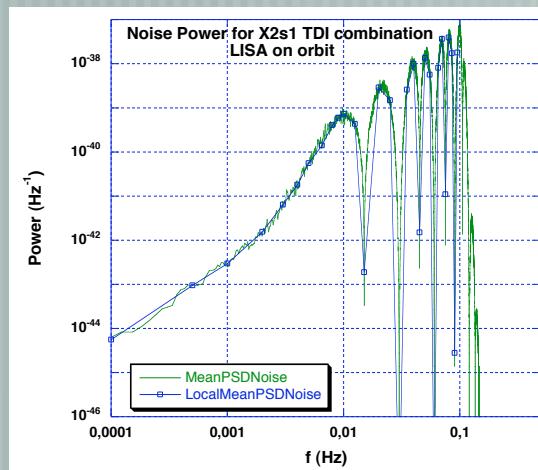
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Modifying the Armlengths L

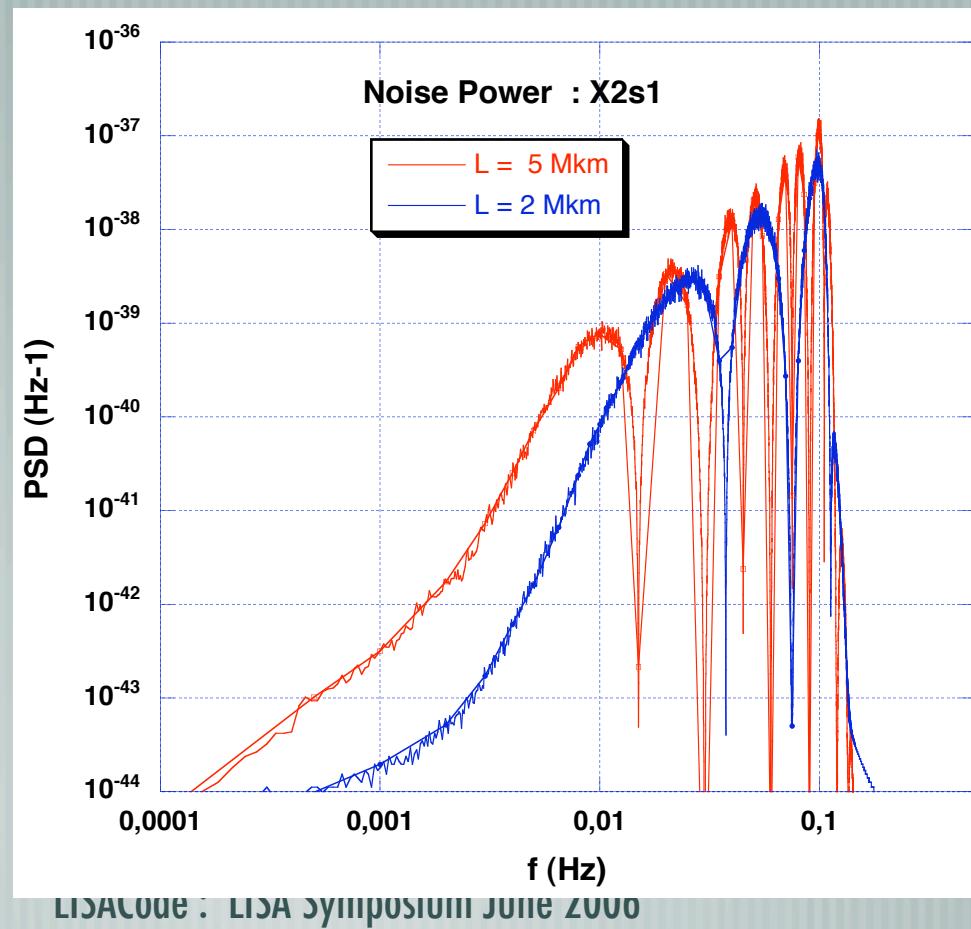
Analysis of table 4.1 of Pre-Phase A Report
Only the shot noise varies with L

Error Source	Error*	Number	Error Reduction Approach
Detection shot noise 1 W laser, 30km optics	11	4	Optimise efficiency of optical chain
Master clock noise	10	1	Ultra-stable oscillators (USO) and correction procedure
Residual laser phase noise after correction	10	1	Use of phase noise correction algorithm
Laser beam-pointing instability	10	4	Active stabilisation of angular orientation of proof masses and spacecraft
Laser phase measurement and offset lock	5	4	Low noise electro-optic design
Scattered-light effects	5	4	Frequency offset; frequency stabilisation of laser to cavity
Other substantial effects	3	32	Careful mechanical and optical design
Total path difference	40		= measurement error in $\mathcal{L}_2 - \mathcal{L}_1$



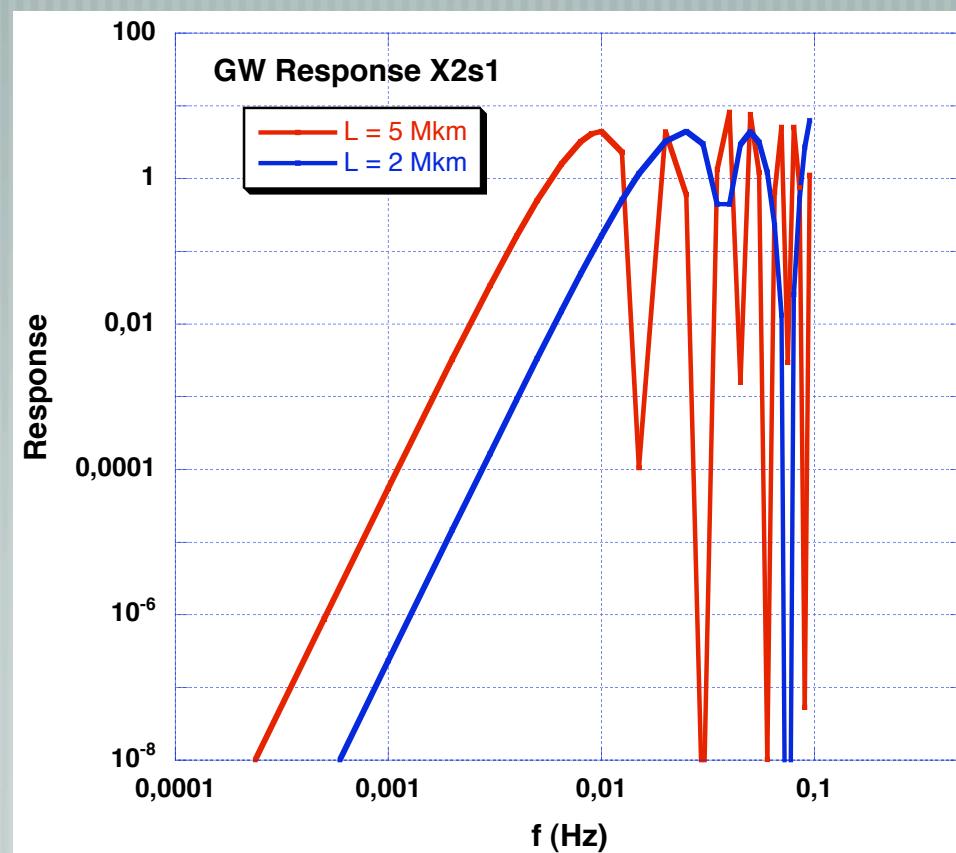
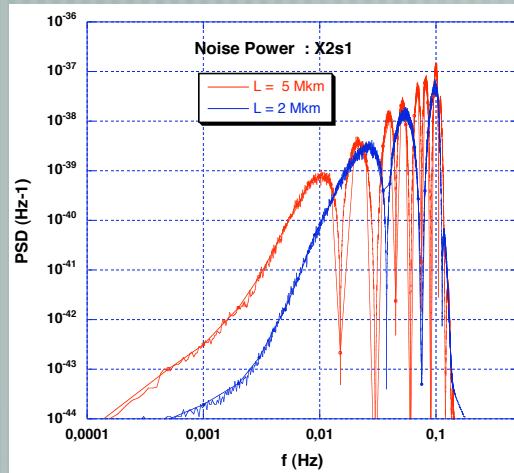
Modifying the Armlengths L

[Analysis of table 4.1 of Pre-Phase A Report



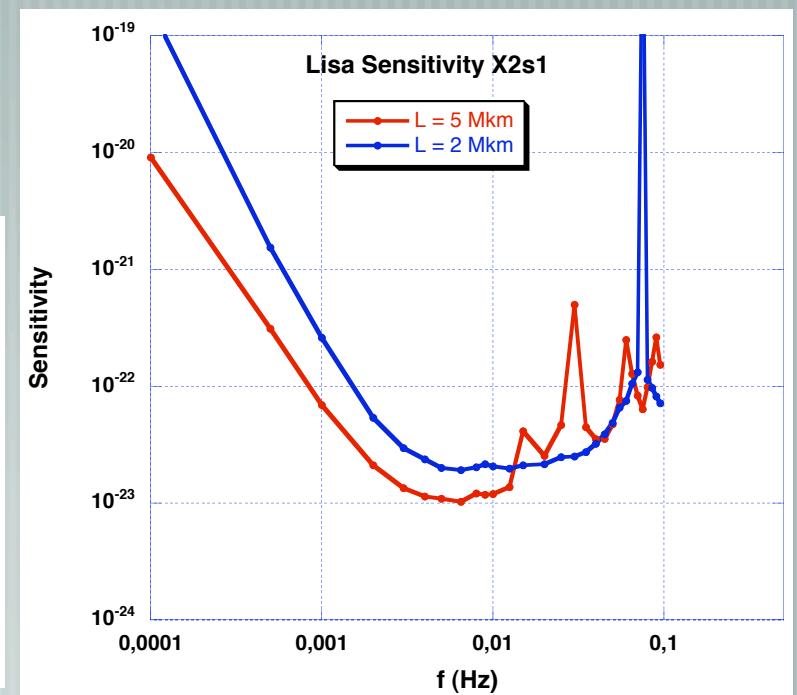
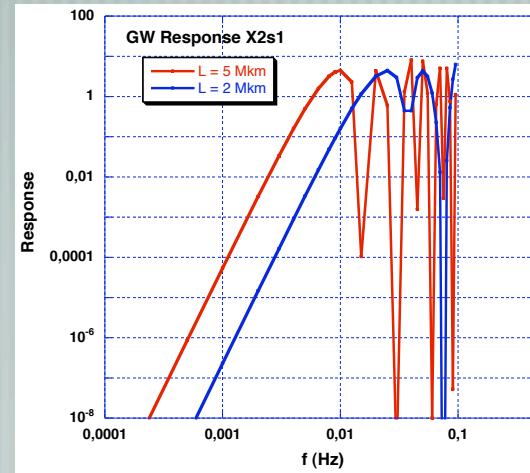
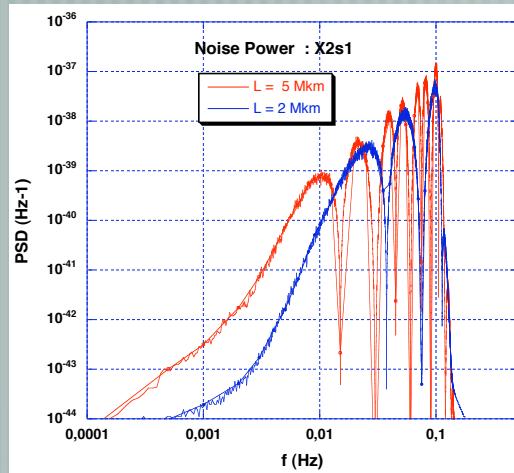
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Modifying the Armlengths L

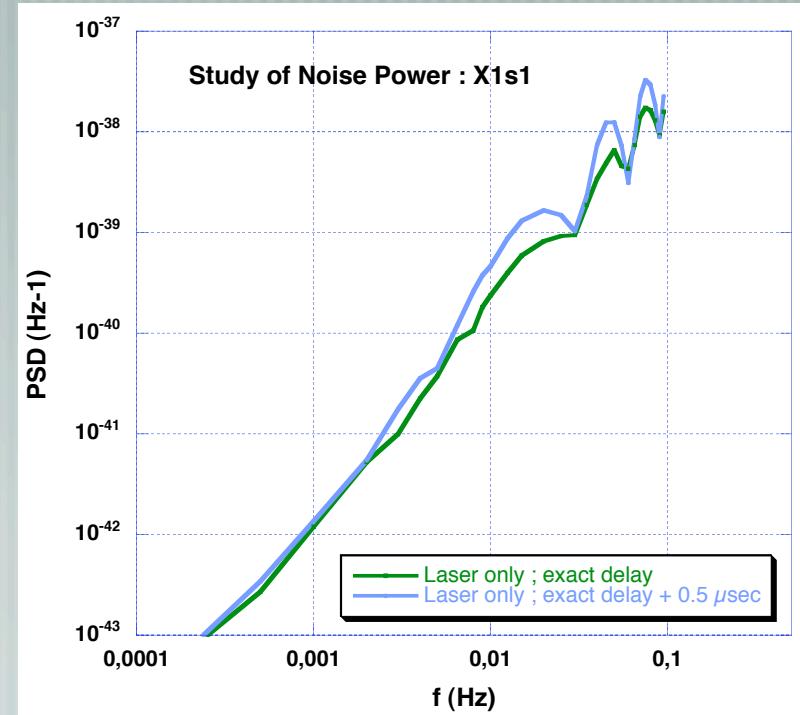
Analysis of table 4.1 of Pre-Phase A Report



Introducing an “error” on the delays

[An “offset” on the delay (or in the armlength) introduces an error on the application of TDI : interpolation of the phasemeter data.

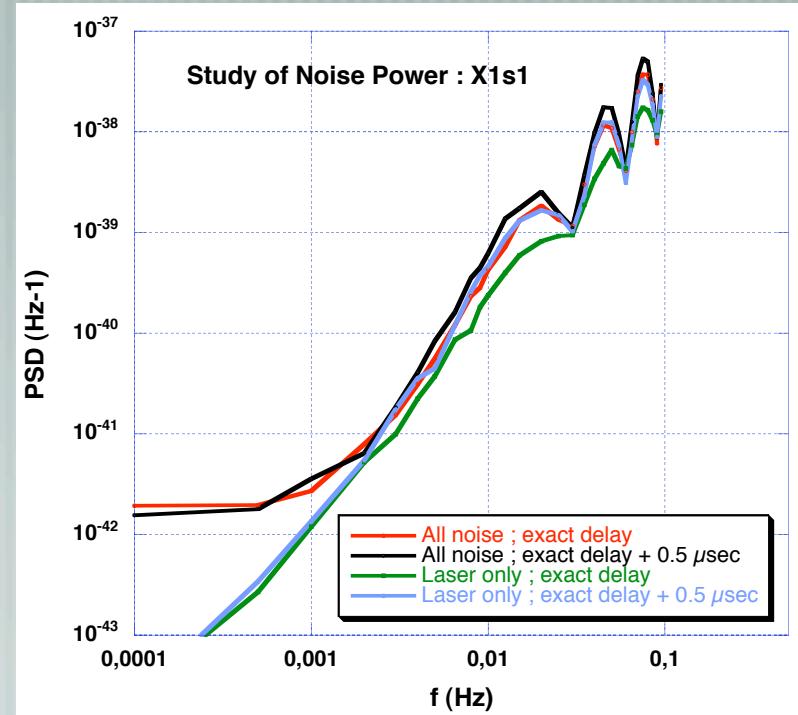
[degradation of the sensitivity.



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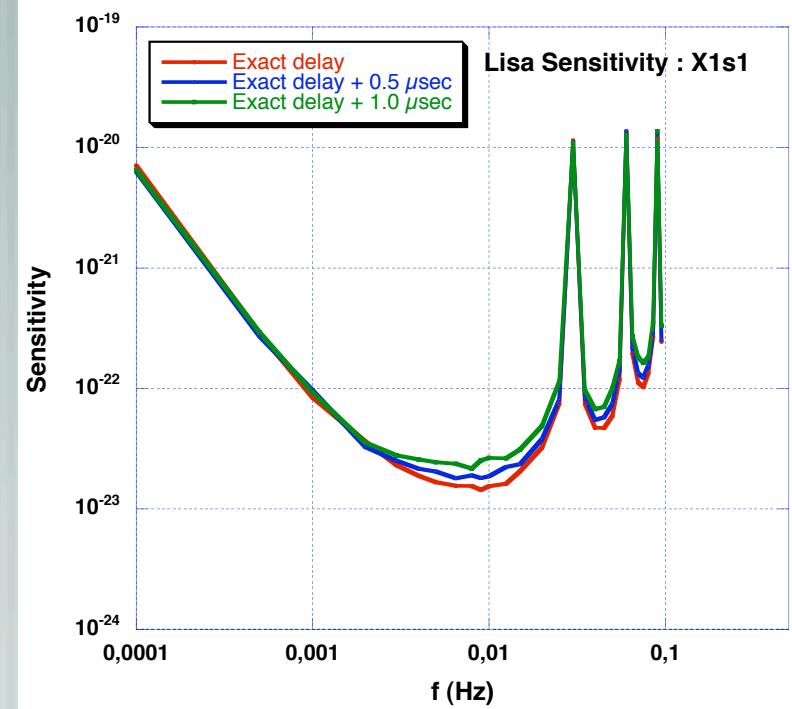
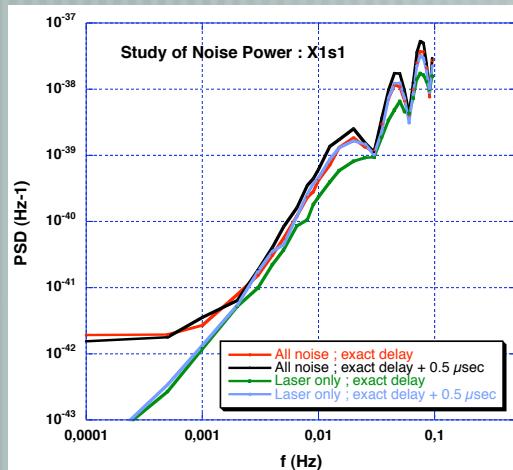
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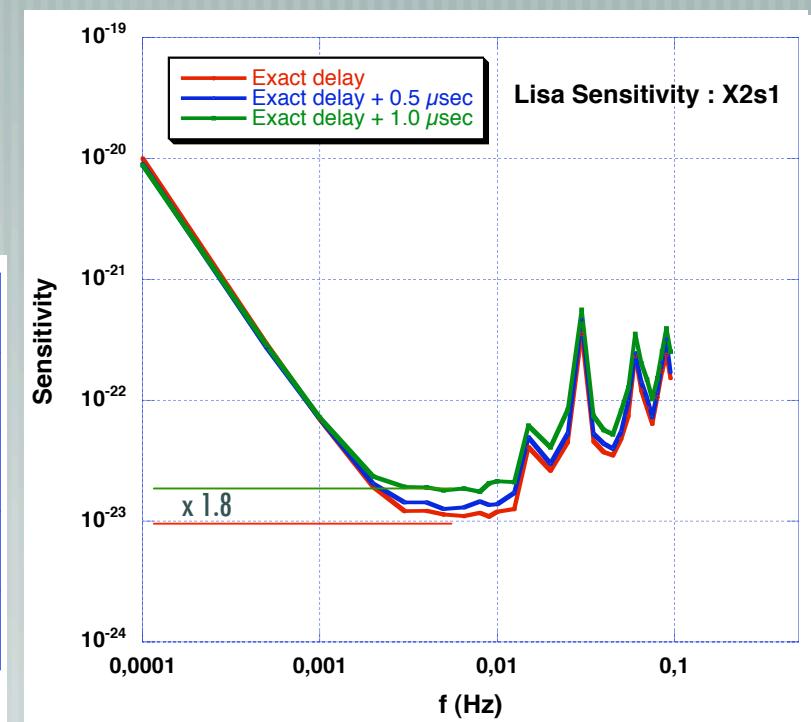
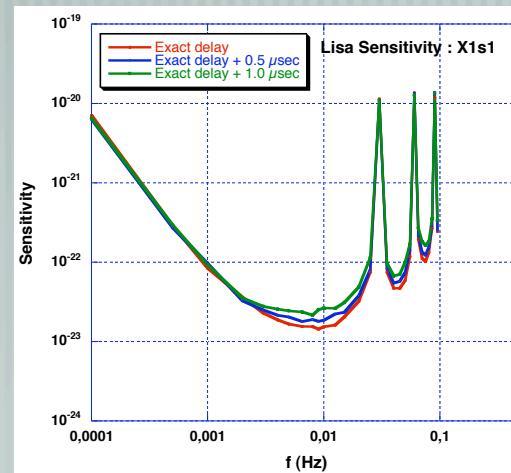
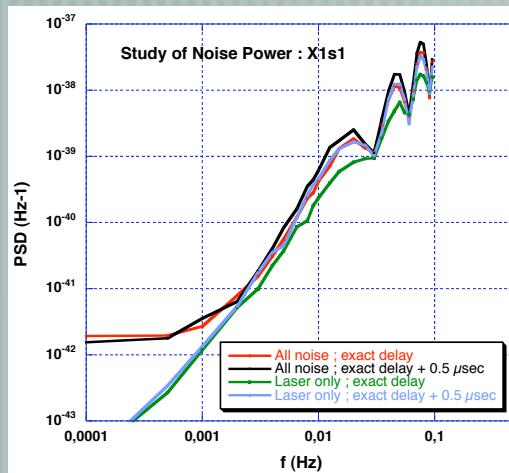
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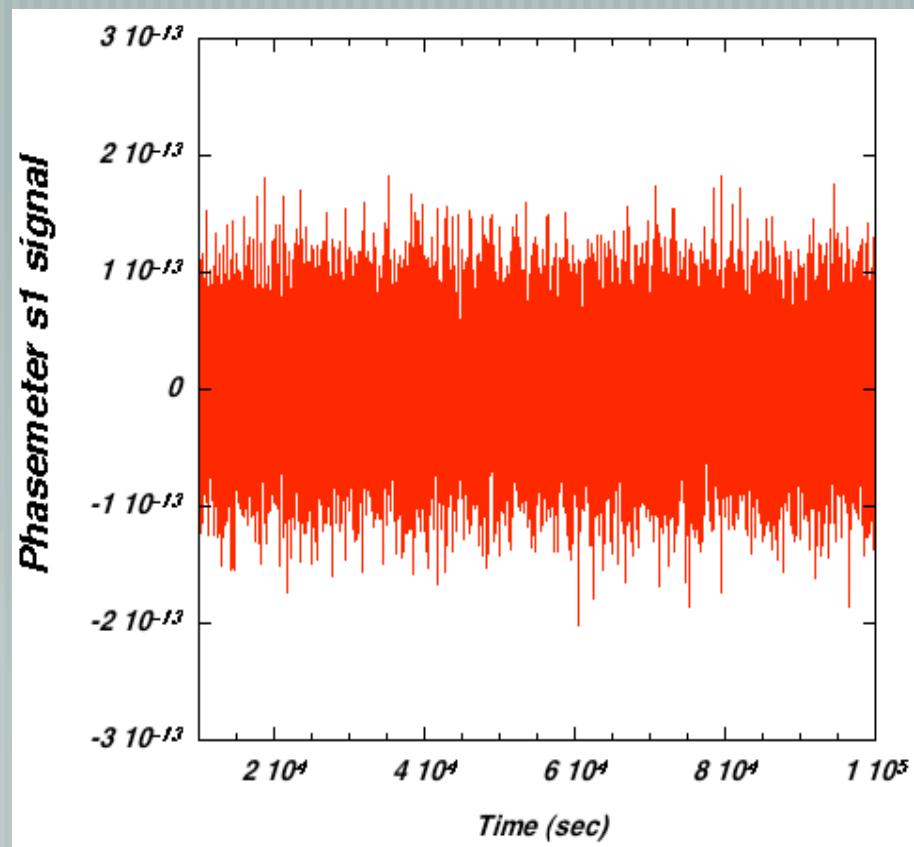
[degradation of the sensitivity.



GW : an example

A Gw is
hidden in
there !

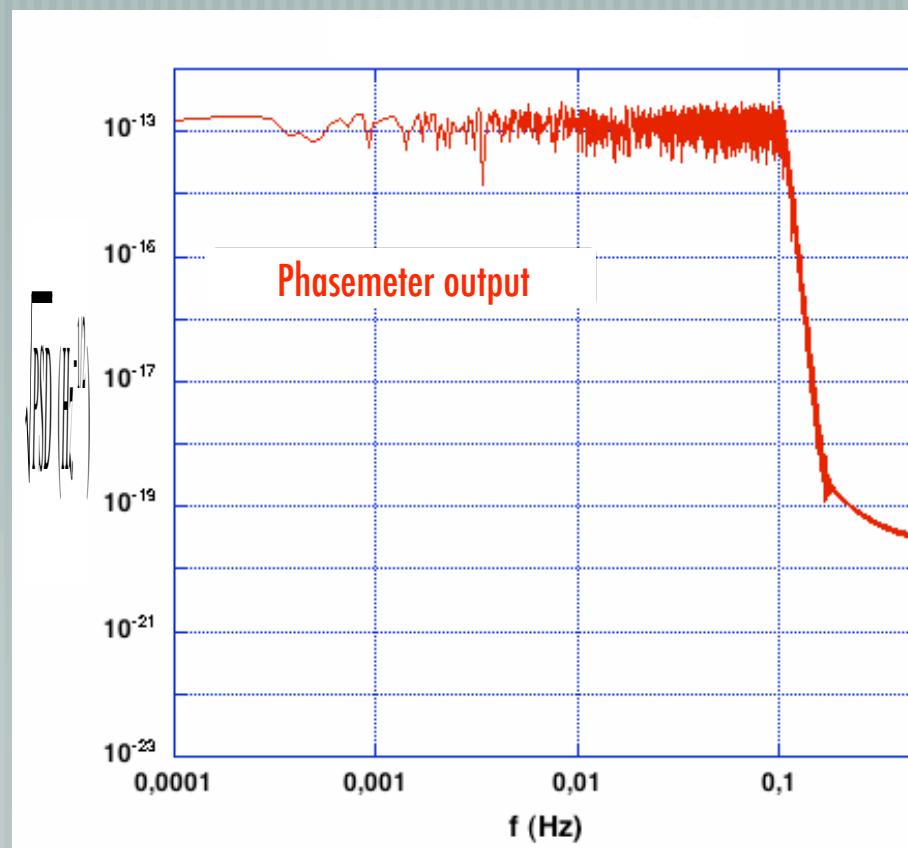
[The laser noise is modelled by a bandwidth limited white noise at 30 Hz/Hz^{1/2}.



GW : an example

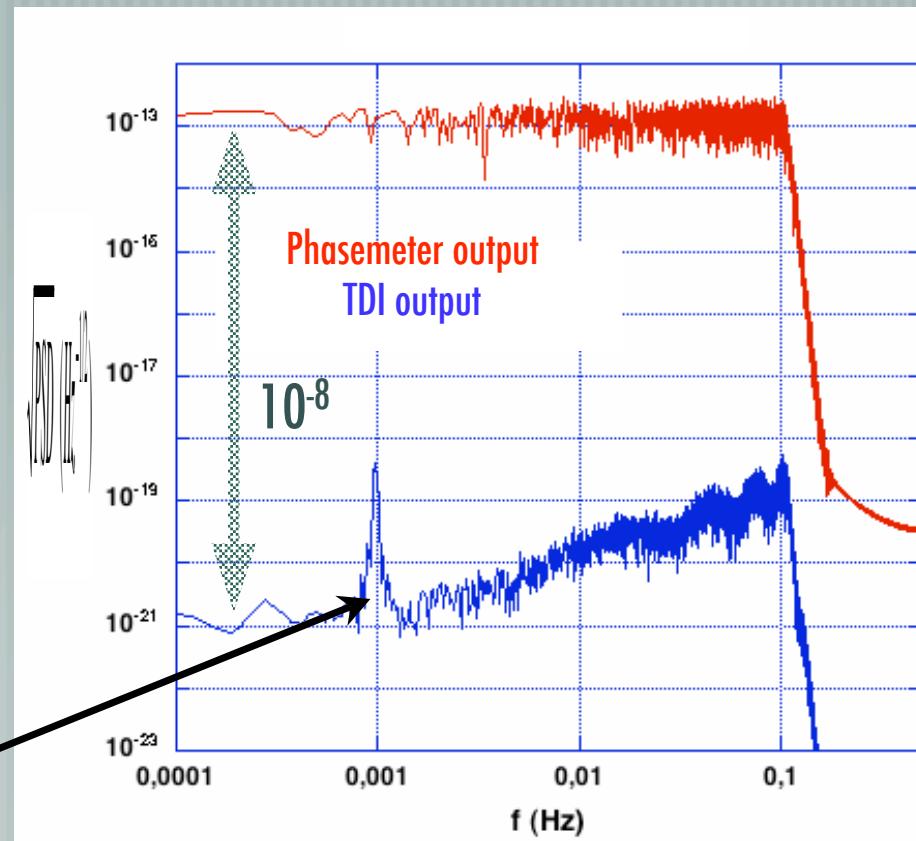
[The laser noise is modelled by a bandwidth limited white noise at $30 \text{ Hz}/\text{Hz}^{1/2}$.

A Gw is
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there !



GW : an example

[The application of TDI recovers the GW signal (Lagrange 20 pt interpolation)].

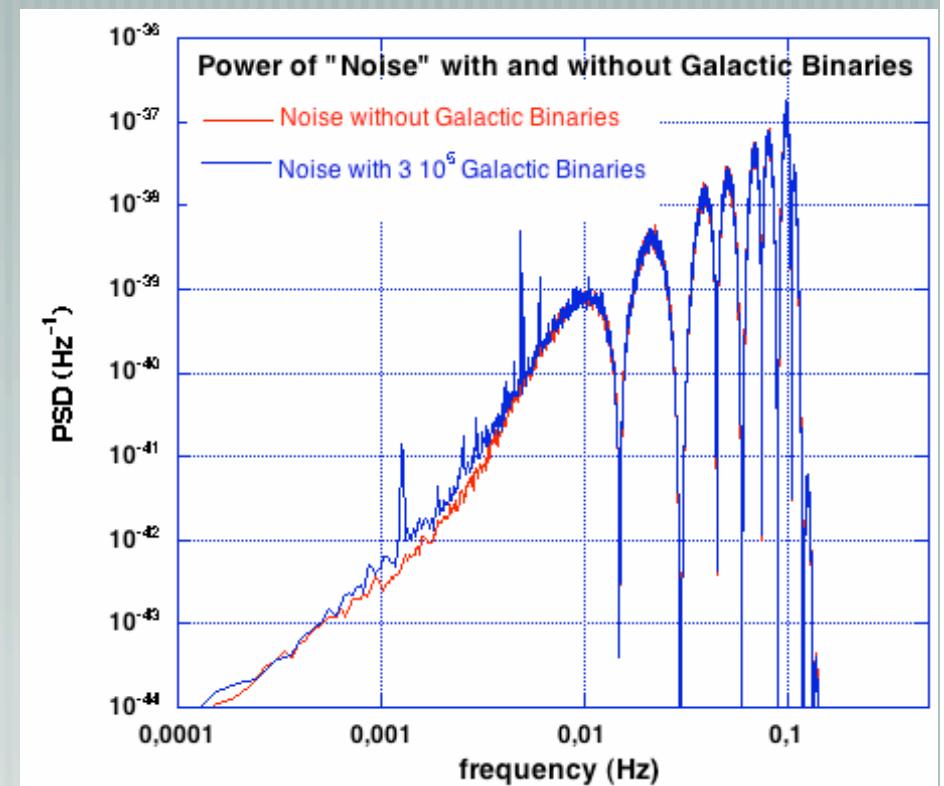


Here it is !



The Galactic confusion noise

- This is on-going work
- The aim is to generate the background associated to $3 \cdot 10^7$ binaries
- These binaries are randomly selected from the Hils-Bender distribution
- This is a challenge for a code operating in the time domain
- The background for $3 \cdot 10^5$ binaries has been calculated
- We are thinking on how to proceed from there !



Status and Evolution of the code

LISACode is finalised : present version 1.1

- GW : monochromatic, binaries, input files,
- Realistic orbits,
- Noise : Laser, inertial mass, shot noise,
- Phasemetre : filtering and sampling,
- TDI : 1st and 2nd generation. Non standard combinations are possible,
- Inputs by ASCII files for configuration files and GW, output by ASCII files.

Executes on most platforms : Mac, Unix, Windows

The future ...

- XML inputs/outputs
- Galactic confusion noise (finalised)
- more inbedded GW types : MBHB, EMRIs,
- more complex noise functions, phasemeters,...
- ...



The Developers

- [A.Petiteau (APC)]
- [G.Auger (APC)]
- [H.Halloin (APC)]
- [S.Pireaux (Artemis)]
- [E.Plagnol (APC)]
- [T.Regimbeau (Artemis)]
- [J.Y.Vinet (Artemis)]



Summary

- [LISACode exists and is operational]
- [We hope many will use it and help to develop it.]
- [We plan to participate to the Mock Data Challenge
 - generation of data and analysis/
- [The Web site : <http://www.apc.univ-paris7.fr/LISA-France/analyse.phtml>]
- Simplified User Manual and examples (we can help !)



Merci !